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(71) Applicant: **NCR INTERNATIONAL INC.**
Dayton, Ohio 45479 (US)

(72) Inventor: **Leong, Llem H.**
Angus, Dundee DD5 3SF (GB)

(74) Representative: **Irish, Vivien Elizabeth et al**
International IP Department,
NCR Limited,
206 Marylebone Road
London NW1 6LY (GB)

(54) An apparatus for validating sheets

(57) A self-service deposit terminal (10) is arranged to validate deposited bank notes. Each note (38) is individually transported past an interferometer (36) which is connected to a control unit (46). The output of the control unit (46) is input into a data processing means (26) which generates a value indicative of the surface roughness of the bank note. The value of roughness is compared with at least one stored reference value for genuine notes. The data processing means determines either solely on this comparison, or in conjunction with the output from a further validation means, whether the tested note is invalid.

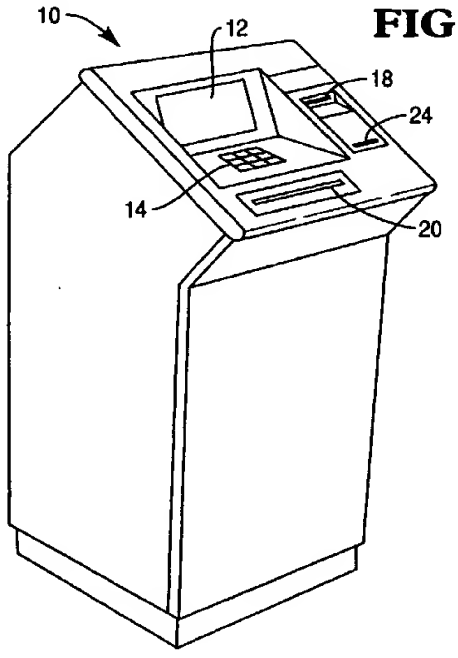

FIG. 1

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Description

The present invention relates to an apparatus for validating sheets such as bank notes.

Bank notes have many features that make it difficult to forge them. However, forgers can now recreate many of these features such as threads and watermarks. The spectral properties of forged notes can now match very closely to genuine notes. Thus, it is now difficult for sales staff in retail establishments to distinguish between genuine or forged notes.

Validation is a problem in self-service deposit terminals where there is no human interaction to check for forgeries.

It is an object of the present invention to provide a new apparatus for validating sheets which does not involve an assessment of spectral properties of sheets.

According to the present invention there is provided an apparatus for carrying out a validation procedure in respect of sheets, characterized by illuminating means for successively illuminating separate areas of a sheet, optical sensing means for receiving light reflected from said areas of said sheet and for producing an optical response dependent on the roughness of said areas, first processing means for receiving said optical response and for producing electrical output signals indicative of the roughness of said areas, and second processing means connected to said first processing means and for making a determination, on the basis of said electrical output signals, as to whether said sheet is invalid.

It should be understood that the roughness of linen-based paper used for bank notes and the raised print printed on them give bank notes a distinctive feel. In the context of the present invention, the roughness of a sheet is determined by the magnitude of protuberances or recesses (normally microscopic in the case of a bank note) in the surface of the sheet and the steepness of the sides of such protuberances or recesses.

Also in the context of the present invention, it should be understood that the term sheet can cover a relatively stiff item such as a magnetic card.

One embodiment of the present invention will now be described by way of example with reference to the accompanying drawings, in which:-

Fig. 1 is a perspective view of a self-service deposit terminal in which a note validator in accordance with the invention is included;

Fig. 2 is a block diagram of the deposit terminal of Fig. 1;

Fig. 3 is a schematic representation of a note validator according to the invention included in the terminal of Fig. 1; and

Fig. 4 is a plan view of a note showing the area scanned by the note validator of Fig. 3.

Referring to Figs. 1 and 2, the self-service deposit terminal 10 shown therein includes a display 12 for displaying user information, a key pad 14 for inputting data, a card reader 16 for receiving a user identity card via a card slot 18, a deposit slot 20 in which bank notes can be deposited, a receipt printer 22 for printing a receipt acknowledging a deposit made by a user and for issuing the receipt to the user via a slot 24, and data processing means 26 to which the display 12, the key pad 14, the card reader 16 and the receipt printer 22 are connected. A note validator 28 in accordance with the invention (to be described in more detail later) and note transport means 30 are also connected to the data processing means 26, the transport means 30 serving to transport deposited notes along paths indicated by arrows 32 in Fig. 3 under the control of the data processing means 26.

To make a deposit, a user inserts his identification card in the card slot 18 of the terminal 10. Data contained in a magnetic strip on the card is read by the card reader 16 and transmitted by the data processing means 26 to a host computer 34. If the host computer 34 authorizes the card then the user can proceed with his deposit by first entering details of the transaction, e. g. the amount of the deposit, by means of the key pad 14, and then by depositing bank notes in the slot 20 with their long edges parallel to the slot 20. A shutter (not shown) blocks the deposit slot 20 a set time after the deposited notes are drawn into the terminal 10. If the notes are placed with their short edges parallel to the slot 20, the shutter would close on the notes before they are fully drawn into the terminal 10. The notes could then be released from the shutter by the user and deposited correctly with their long edges parallel to the slot 20.

Referring now to Fig. 3, the deposited notes are separated out by conventional means (not shown) and individually passed along a feed path (shown by arrow 32) by the transport means 30 (Fig. 2). The feed path 32 takes each note through the note validator 28 inside which the note is passed in front of an optical sensor 36. The optical sensor 36 is an interferometer which is mounted so that the axis of the sensor is perpendicular to the feed path 32, the end of the interferometer adjacent a note 38 present in the validator 28 being positioned between approximately 5 and 16 millimetres from the note 16. Various interchangeable focusing lenses can be used on the interferometer 36 to achieve a location within this range. The interferometer 36 focuses a small spot of light (typically about 10 millimetres in diameter) on the surface of the note 38.

The notes are transported past the interferometer 36 by pairs of rolls 40,42. The rolls 40,42 form part of the transport means 30 which is under the control of the data processing means 26.

The interferometer 36 is connected by a fibre-optic cable 44 to a control unit 46. The control unit 46 is a conventional piece of equipment. Such a control unit, known as Interscan Surface Measurement System, is available from Techtab, Metz, France. The control unit

46 comprises a laser 48 and an optical processing unit in the form of a fast electro-optic fringe tracking servo 50. The laser 48 produces coherent light that is sent via the cable 44 to the interferometer 36.

A conventional optical edge sensor 52 is also mounted inside the note validator 28 on the side of the feed path 32 opposite to the interferometer 36. This is used to indicate to the data processing means 26 that a note is just beginning to pass the interferometer 36. A timing disc 54 and sensor 56, attached to one of the rolls 42, serve as timing means for the data processing means 26. On the basis of the outputs of the sensors 52 and 56, and as illustrated in Fig. 4, a narrow strip 58 of the bank note 38 is defined to be scanned by the validator 28 where, as mentioned before, arrow 32 represents the direction of travel of the note 38 through the note validator 28.

A note is typically transported through the note validator 28 at a speed of 10 metres per second. The control unit 46 takes 15 samples of the output from the interferometer 36 for every millimetre of the note. Thus the note validator 28 is operating at a frequency of 150 kHz. In effect, the strip 58 is made up of a large number of small surface areas of the note 38 spaced along the length of the strip 58, these areas being successively illuminated by light emanating from the interferometer 36. Each area is that area of the note 38 which is illuminated at the time the output of the interferometer 36 is sampled by the control unit 46.

In known manner, the interferometer 36 collects light reflected from the areas of a note 38 on which coherent light emanating from the interferometer 36 is incident. Also, in known manner, the interferometer 36 transmits to the fringe tracking servo 50 of the control unit 46 over the fibre-optic cable 44 interference fringes resulting from the phase difference between the light emanating from, and the reflected light received by, the interferometer 36. It should be understood that this phase difference is dependent both on the angle to the horizontal of said area of the note (the greater said angle the greater is the phase difference) and also on the distance of said area from the interferometer 36 (the greater said distance the greater is said phase angle). In other words, the phase difference is dependent on the light or depth of a microscopic protuberance or recess in the surface of the note in which said area may lie and also on the steepness of the sides of such protuberance or recess. In this connection it will be appreciated that the magnitude of protuberances and recesses in the surface of a note and the steepness of the sides of such protuberances and recesses determine the roughness of this surface.

Also, in known manner, the fringe tracking servo 50 generates an output voltage whose magnitude is dependent on the above mentioned phase difference for each area of the surface of a note sampled by the validator 28. The output voltages of the fringe tracking servo 50 are converted by the control unit 46 into a series of digital signals which are applied to the data processing means 26 and which provide an indication of the roughness of the note 38 sensed by the validator 28. As previously mentioned, the validator 28 scans a narrow strip 58 of the note 38. The digital signals applied to the data processing means 26 in the course of the scanning of the strip 58 are processed by the data processing means 26 to generate a value indicative of the roughness of the note 38. This value is compared by the data processing means 26 with one or more ranges of reference values for genuine notes that are stored in memory location 60 of the data processing means 26. If the value measured by the interferometer 36 is within a stored range of values then the note is determined by the data processing means 26 to be potentially valid. However, it should be understood that the validator 28 only serves as a secondary validation system as regards notes fed along the feed path 32. Thus, the validator 28 works alongside a known primary validation system 62 (Fig. 2 - not shown in Fig. 3) such as one based on the spectral analysis of light reflected from a note. The primary validation system 62 is also connected to the data processing means 26, and the data processing means 26 makes a determination as to whether or not a note fed along the feed path 32 is valid based upon the outputs of both the secondary validator 28 and the primary validator 62.

If a note is accepted as valid, then a divert gate 64 remains in its home position shown in solid outline and the note is fed to collection means 66. If a note is rejected as invalid, then the data processing means 26 rotates the divert gate 64 into the position shown in chain outline by means of an actuator 68 (see Fig. 2), and the note is fed to a rejection bin 70.

If a note has a very fine finish then a smaller focused spot size would be required at the surface of the note to allow good resolution of the surface features. A small spot size, however, limits the depth of field and only small height features are measured. Surfaces having a fine finish usually have moderate to low slope angles as regards the sides of microscopic protuberances and recesses in the surface, and reflected light is usually within the collection aperture of the interferometer 36. If there are severe microscopic roughness features that have steep angles the reflected light may not be collected by the interferometer 36 from these positions. Surfaces with greater roughness require larger spot sizes. Larger spot sizes increase the depth of field and larger height changes in the sensed areas of a sheet surface can be measured.

An advantage of note roughness measurement by the note validator 28 is that the sensor (i.e. the interferometer 36) does not actually make contact with the notes thus avoiding frictional wear.

Experts can pick out a forged note by feeling the roughness of the surface of the note. This invention gives an equivalent result using a machine, and can be used to detect forged notes in any automated currency handling system. It can also be used in a device to aid

sales staff in detecting forged notes.

The validation apparatus described above can also be adapted to validate identity cards that are inserted into a card reader. These identity cards would have an area where the surface roughness has been varied either by the manufacturing process of the card or by a physical property of the medium such as embossing to make the card unique to a user.

An alternative to feeding in bank notes by hand is for them to be picked by conventional pick means from currency cassettes and then to be individually fed automatically through the validator 28.

Claims

1. An apparatus for carrying out a validation procedure in respect of sheets, characterized by illuminating means (36,44,48) for successively illuminating separate areas of a sheet, optical sensing means (36) for receiving light reflected from said areas of said sheet and for producing an optical response dependent on the roughness of said areas, first processing means (50) for receiving said optical response and for producing electrical output signals indicative of the roughness of said areas, and second processing means (26) connected to said first processing means and for making a determination, on the basis of said electrical output signals, as to whether said sheet is invalid.

2. An apparatus according to claim 1, characterized in that said illuminating means (36,44,48) illuminates said areas of said sheet with coherent light, and in that said optical sensing means is an interferometer (36) which forms part of said illuminating means (36,44,48) and which produces an optical response in the form of interference fringes resulting from the phase difference between light emanating from said interferometer and reflected light received by said interferometer.

3. An apparatus according to claim 2, characterized in that said first processing means (50) incorporates fringe tracking means arranged to generate a voltage whose magnitude is dependent on said phase difference.

4. An apparatus according to any one of the preceding claims, characterized in that said second processing means (26) is arranged to generate a value indicative of the roughness of said areas of said sheet, and is arranged to make a determination as to whether said sheet is invalid by comparing said value with at least one stored range of values.

5. An apparatus according to any one of the preceding claims, characterized by transport means (30) for transporting sheets individually along a feed path (32) past said optical sensing means (36).

6. An apparatus according to claim 5, characterized in that said illuminating means (36,44,48) is arranged to successively illuminate areas of a sheet lying in a strip extending in a direction parallel to the direction of feed of the sheet along said feed path.

7. A self-service deposit terminal (10) including an apparatus according to either claim 5 or claim 6, characterized in that said transport means (30) transports deposited bank notes individually along said feed path (32) past said optical sensing means (36), and in that said second processing means (26) makes a determination as to whether a bank note is invalid.

8. A self-service terminal according to claim 7, characterized by divert means (64), collection means (66), and a reject container (70), said divert means being arranged to divert bank notes which have been determined to be invalid into said reject container, and to permit bank notes which have not been determined to be invalid to be fed to said collection means (66).

9. A self-service terminal according to claim 8, characterized by further validation means (62) arranged to make a determination as to whether a deposited bank note is invalid on the basis of one or more criteria other than the surface roughness of the note, said divert means (64) being arranged to divert a deposited note to said reject container (70) if both said further validation means (62) and said apparatus according to either claim 5 or claim 6 make a determination that the note is invalid.

FIG. 1

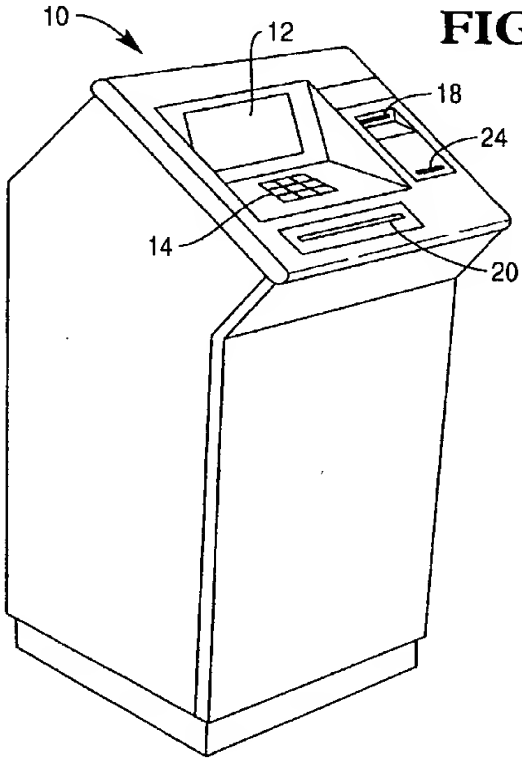
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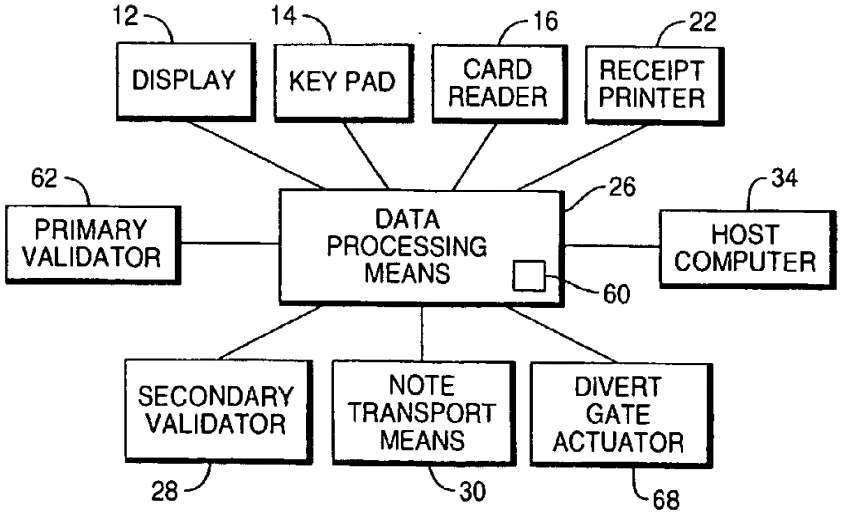
FIG. 2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DISPLAY
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KEY PAD
16
CARD READER
22
RECEIPT PRINTER
62
PRIMARY VALIDATOR
DATA PROCESSING MEANS
26
60
34
HOST COMPUTER
SECONDARY VALIDATOR
28
NOTE TRANSPORT MEANS
30
DIVERT GATE ACTUATOR
68

FIG. 3

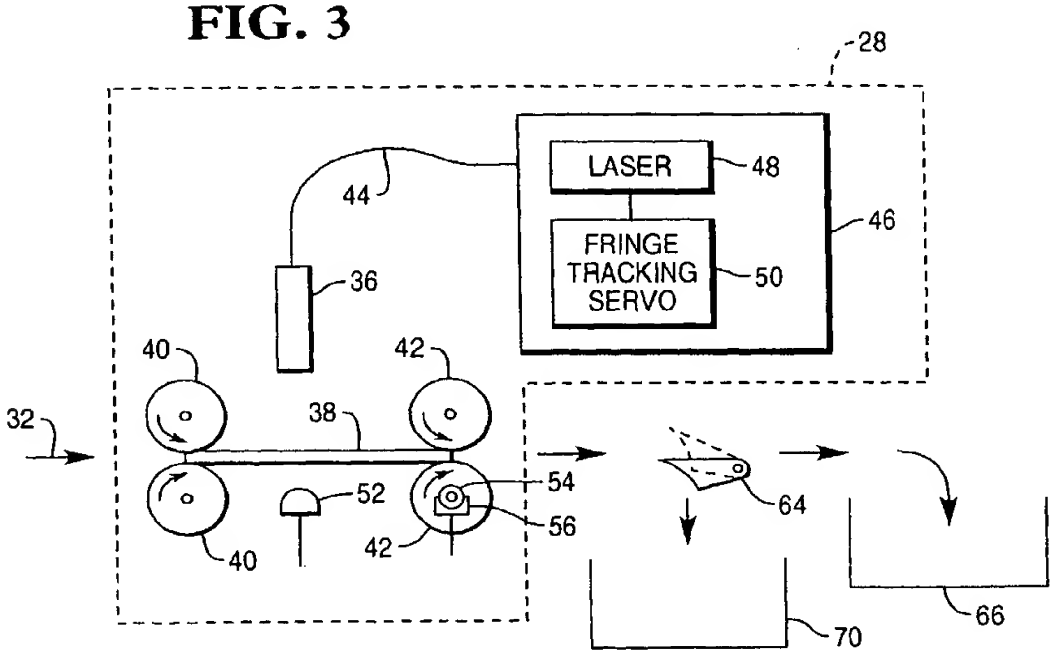
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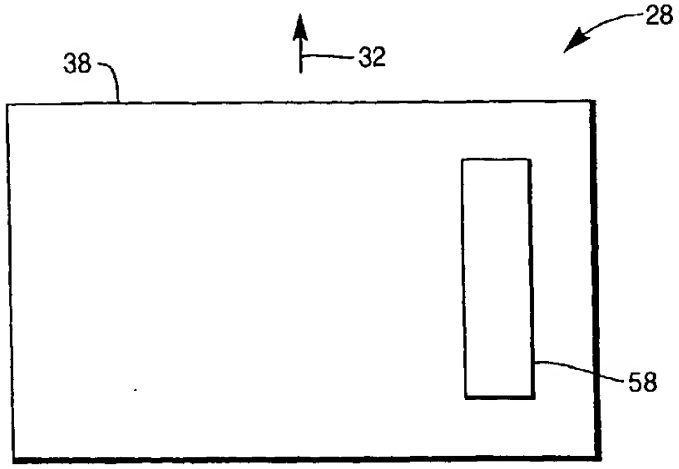
FIG. 4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